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The invention relates to a machining head as well as a method for the surface processing of workpieces by means of laser beam, with which performed using a supplied powdered welding-rod materials, a coating, an alloying up in the range near the surface or a dispersion of an edge zone of the base material with powder particles can become, so that the geometry and/or the surface properties of a workpiece targeted affected to become to be able. The invention is suitable thereby in particular for applications, becomes performed with which between the used laser beam and the workpiece a relative movement and this relative movement exhibits frequent alternate directions. The solution according to invention can for coating, regenerating tools and components, like z. B. find to the metal figuration, the cutting engineering for the Gessereitechnik, as well as in the engine and turbine construction use. In addition it is for those the bottom preambles "rapid prototyping" and rapid Tooling" falling processing methods suitable.

Of E. Beyer and K. Knowledge brook is in "surface treatment with laser radiation"; Springer publishing house; 1998, sides 300 and 301 on possibilities to the pneumatic promotion of powders and and. A. also referred to so called coaxial nozzles, whereby a laser beam can likewise become by such a partially hollow nozzle on a workpiece its surface heating directed and a powder gas stream by such a nozzle as itself conical tapering hollow jet on the surface of a workpiece directed.

Besides is from US 4.724.299 a corresponding machining head known, which exhibits a split housing. The two parts of this housing can become teleskopförmig in purchase shifted to each other, in order to create a possibility, to co-ordinate the focus situation of a powder jet with the focus situation of the laser beam so that this powder jet becomes already heated before the impact on the surface of a workpiece. Both the powder jet, as well as the laser beam common must by a cone-shaped opening. For this however a corresponding diameter of such a cone-shaped opening is required and accordingly becomes a cylindrical powder jet with corresponding size on the surface of a workpiece directed, so that the powder in the excess supplied will be registered and corresponding high powder losses is.

In US 5.418.350 there is a powder supply in connection with a laser working on head described, becomes used with which a nozzle, over the powders by at least a conical annular gap on the surface of a substrate guided and by means of a laser beam is melted.

With this solution the powder with a gas flow over powder inlets introduced and it arrived over in a perforated disc formed bores into a relative large sized chamber. In the chamber swirls arise, which can lead in particular with powders, whose single components exhibit different densities, to the separation. From this chamber the powder arrives more immediate into a conical annular gap, by whose cross section decrease an increase of the conveying speed arises, which affects adverse the utilization of powder and the layer education procedure. Due to the swirl in the chamber alternate pressure ratios and therefore also alternate conveying speeds can occur, so that the required powder rate temporal can change, whereby this in particular when applying layers or the formation of desired contours such workpieces negative affects.

At the there described apparatus an outside cooling system attached, with however not necessarily those critical areas the sufficient cooled particularly to become to be able and in addition between coolant and inner one, is which are appropriate for complete wall of the housing part.

It is object of the invention to create a possibility with which a surface processing can become performed by means of laser beams, with which a powder supplied becomes, whereby the supplied powder mass flow can become also direction-independent almost constant and the powder hollow jet uniform held.

This object with the features of the claim 1 dissolved becomes according to invention. Favourable arrangement forms and developments of the invention result with the features contained in the subordinate claims.

A machining head according to invention can accomplish relative to a workpiece surface in at least two axial directions a relative movement in purchase to the workpiece, whereby upon such a machining head alone, the workpiece alone or machining head and workpiece common corresponding moved to become to be able, so that a rapid and local targeted surface processing through put from tracks, also with frequent direction change, possible is.

The machining head is so that guided by it a laser beam, constructed with the fact, an adjustable beam spot on the surface of a workpiece can become training. For this an housing corresponding formed, so that a cavity, parallel is to longitudinal axis of the laser beam present, by which the laser beam corresponding focussed on the workpiece surface directed is become can.

Within the housing a turbulence chamber is rotationally symmetrically formed, in a powder gas stream by at least one flowing in opening, around the cavity, becomes guided by which the laser beam, preferred in the upper part of the turbulence chamber, introduced becomes. In the turbulence chamber a made uniform distribution of the powder in form of a coaxial powder cloud forming as the laser beam as well as an intense mixture of the powder. The turbulence chamber flows itself in its bottom portion, preferred over a conical tapering bellmouth into several parallel to longitudinal axis of the

laser beam of arranged calming channels, which radial-symmetric and in equal distance, distributed over which periphery, arranged are. The calming channels flow themselves then into a conical in the direction of the surface of the material tapering annular gap, in which no bar or other turbulence elements is contained. The powder withdraws then from the annular gap, as itself likewise conical tapering powder hollow jet, whereby the focal point of this conical tapering powder hollow jet lies outside of the housing and therefore also outside of the machining head. Favorable way becomes the annular gap so formed and exhibits corresponding inclination angles that it is formed bottom consideration of the distance as the surface of the workpiece a conical tapering powder hollow jet, whose focal point lies more immediate on the workpiece surface.

The size of the point of focus of the powder hollow jet should correspond thereby, at least to the approximate size of the beam spot of the laser beam on the surface of the workpiece, so that an optimum utilization of powder can become achieved.

With between the turbulence chamber and the annular gap arranged the calming channels, in particular by their parallel alignment to longitudinal axis of the laser beam and also their form and dimensions can become an uniform powder promotion with very small powder mass flow fluctuations below 5% achieved, so that during a corresponding surface processing of a workpiece essentially on additional measures, like z. B. a control of the laser power to be done without can and nevertheless a targeted layer structure and/or. a targeted interference of surface areas by alloyage and/or. Dispersion at a workpiece achieved to become to be able.

The calming channels should exhibit a length of at least 10 mm, in order to reach the desired effect.

Favourable way also two flowing in openings present can be, those preferred, actual radial opposite sides of the turbulence chamber arranged are at the turbulence chamber. Thereby it is also possible to use powders various composition which can become then homogeneous mixed in the turbulence chamber and then as homogeneous blend over the calming channels and the annular gap on the surface directed.

The calming channels become favorable-prove so dimensioned that the sum of their free cross sections at least not small as the free cross section the one and/or. several flowing in openings is. This leads to the fact that in the turbulence chamber, which calming channels and in the annular gap almost constant pressure ratios and flow rates achieved lead to become to be able, those, as already mentions, to an uniform promotion of the powder.

▲ top It in addition, if the housing from two parts is formed, those are favourable along the longitudinal axis of the laser beam relative, as with a telescope, to each other shifted to become to be able. The two parts also the annular gap are formed, by corresponding conical tapering formed walls. Made one now a corresponding relative movement of the two portions of the housing, can become the clearance of the annular gap varied, whereby the cone angle is maintained. By this variation of the clearance of the annular gap influence on instantaneous required powdering Rome and the diameter and the cross-section area of the powder jet on the workpiece surface can become taken. A relative small time constant can become achieved, which is smaller substantial, than this with a control of the powder of gas flow introduced into the turbulence chamber the case is.

The two parts of such an housing can be by means of conventional threads connected, whereby is possible with corresponding small slope of such a thread a very accurate adjustability of the clearance of the annular gap. Most simply an adjusted position of the two parts of an housing can become by means of conventional lock nut found.

In addition, it exists the possibility to plan an additional rotary drive possible with which an adjustment of the clearance of the annular gap is also during the processing. This adjustment can affect itself favorable, if a movement in almost opposite direction, thus at such turning points, performed will or it can become the powder promotion very rapid interrupted, if dead ways, D. h. Ranges of a workpiece surface to be exceeded, which are to remain uninfluenced, traveled become.

In place of such a rotary drive also a corresponding suitable linear drive can become used, with which this relative movement of the two portions of the housing can become performed.

In simplest form for this also an electromagnet can become used, which is to become however preferred used if only an opening and a closing movement of the annular gap required are.

Becomes the annular gap with one of the above variants closed or that powdering Rome on the surface of the workpiece, z. B. by locking the laser working on head at its side disabled pointing to the workpiece surface, it is favorable to close the simultaneous powder supply. For this before the flowing in opening (EN) arranged valve can become closed. More favorable it is however to attach to the turbulence chamber a powder gas exhaust passage which is sealed with normal operation with a valve. However if the annular gap becomes closed, almost simultaneous this valve should become opened, in order to avoid a pressure rise and an increased accumulation of powder in the turbulence chamber. The powder gas exhaust passage is favourable with the powder storage vessel connected, from which the powder in the rule into the turbulence chamber arrived and so powder losses avoided to become to be able.

Favorable way should consist the housing at least predominant of a material with good heat conduction, so that also a long-term enterprise of a machining head according to invention is possible. The housing can for example from coppers and/or a copper alloy, as exist brass. The two parts of an housing can consist easily of different materials, whereby however their thermal expansion coefficient should become noted.

It is favourable in addition, if the housing and/or. the two parts of such an housing is provided with a verschleissfesten coating/are, as this is for example with nickels or nickel alloys the case. Such a coating can have the other advantage the fact that it exhibits a higher reflectance for the laser radiation and poorer adheres to additional eventual spraying drops.

The undesirable heating of a machining head according to invention, those safer with a long-term enterprise, with the treatment of larger and/or. complex formed workpieces arises, is in the housing cooling an integrated. For this annular ducts, as cooling channels formed, are by the z. B. corresponding water kept at a moderate temperature in the circuit and outside of the machining head over an heat exchanger guided becomes favourable.

By integration of the cooling channels and their arrangement in particularly critical areas, thus also in the vicinity of the

annular gap, a good temperature heat sink can become achieved, so that a reduced heating is to be registered.

At the portion of the housing, which points in the direction of the surface of the workpiece, an additional protective layer can be formed or a corresponding sealing pane arranged. Also here the reflectance characteristics and the surface properties should find with splashes attention.

Favourably it can be in addition, if the particularly stressed parts of a machining head according to invention are more replaceable. This is z. B. a corresponding nozzle tip, which is hollow drilled and by those the laser beam on the surface of the workpiece directed. The outside outer surface of such a nozzle tip can form the inner wall of the annular gap.

Corresponding one can become also one, preferred conical formed outer nozzle used, whereby a cone is both formed at the outside of this outer nozzle, as well as at the inner outer surface. The inner outer surface of this outer nozzle forms then the outer wall of the annular gap. There these parts known-measured relative simple and rapid if necessary exchanged become at the walls of the annular gap by the powder movement and the there safe higher temperatures an increased wear to expect are, can.

With the invention know both single trace, as well as flat coatings, as this is in particular also with free forming-flat the case, when wear and corrosion protection become formed. In addition repair coatings, how they are for example required with material-deforming tools due to breakage or wear, are performed become. In addition, simple and form-complicated bodies generated can become, whereby dense bodies with high mechanical and thermal maximum stress obtained to become to be able. This is for example with methods rapidly prototyping and rapid Tooling the case. With the invention a layer can, in addition, become a multilayer structure of structure with several hundred vertical also horizontal overlapping single traces performed. Since such methods make continuous jet interference times required, which require time of several hours, the formation with the corresponding material selection and the integrated cooling particularly favorable affects itself.

By the high precision, with which the powder supply can become achieved, an high geometric accuracy of the single tracks (width, height, tolerances along the track) can be kept, which to an high figuration regret and small tolerances leads with coatings at contours. In addition form-faithful hollow and volume body with corresponding high dimensional stability can become obtained.

In addition also the material composition in a so manufactured body or a corresponding coating can become relative simple and targeted set. For this various powders or powder mixtures with different mixing ratios can become easily the order provided. So for example only a powder of the turbulence chamber supplied can become and for the interference of certain local areas of a workpiece a temporary, for example at least a second powder into the turbulence chamber introduced become over a certain period.

There made, changes in direction do not play the powder supply coaxial to the laser beam with the relative movement working on head workpiece roller. In same way also the homogeneous powder distribution affects itself over the cross section of the powder hollow jet.

With various methods it can be required to hold by movement of the machining head in vertical direction, the distance between machining head and workpiece surface constant so that the focal point of the powder hollow jet and also the size of the laser beam mark on the surface of the workpiece can become constant held. The machining head can for example with a for this suitable manipulator, like z. B. an industrial robot, a preferred joint arm robot connected its. An industrial robot possible thereby a movement of the machining head in the three at least required degrees of freedom.

With the calming channels arranged between the turbulence chamber and the annular gap achieved becomes that the powder remains calmed down after the Zwangsführung in the calming channels and with defined flow direction and speed the conical tapering annular gap, whose clearance favorable-proves is also more adjustable, to occur itself can. With the annular gap a conical powder hollow jet with a minimum diameter up to 1 mm can become formed. The annular gap forms then the end of the flow channel, so that that becomes powdering Rome by no other nozzle members affected. The focal point of the powder hollow jet is appropriate thereby for general outside of the machining head and thus can the smallest cross section of this powder of hollow jet immediate used become. By the design of the annular gap between the nozzle tip and an outer nozzle a distribution of all powder particles in a core jet in concentrated form achieved and powder dispersions at the nozzle outlet can become avoided as far as possible. From it an high utilization of the supplied powder and process stability result can increased become, since uncontrolled strewn powder becomes avoided as far as possible.

Subsequent one is to become the invention exemplarily described.

Show:

Fig. 1 a sectional view of an example of a machining head according to invention and

Fig. 2 a section along line A-A, in Fig. 1 illustrated example.

With in the Fig. 1 illustrated example of a machining head according to invention, from two parts 4 and 5 formed housings become used, which are 3 connected with one another with a thread, whereby a determination possibility is in a certain position 10 given by an additional lock nut. With the thread 9 the two parts 4 and 5 of the housing can become relative shifted to each other, so that a teleskopförmige displacement parallel can become longitudinal axis of a laser beam 7 achieved.

The laser beam 7 can become using here a not represented strahlführungs and if necessary also a jet figuration unit by the housing part 4 on the surface of a schematic suggested workpiece directed. The focus of the laser beam becomes 7 so set that a certain jet spot size on the surface of the workpiece can become achieved, which agrees in for instance with the size of one point of focus of a powder hollow jet. Can, as in Fig. 1 more discernible, the focus of the laser beam 7 also within the housing of the machining head arranged its.

In not represented form additional the laser beam 7 by the housing part 4 can become also an inert gas on the surface of the workpiece directed, which can prevent an improved cooling to a possible and to the other droplet spraying on from the surface from the penetration into the housing.

Both part 4, as well as part 5 of the housing, 7 formed are rotationally symmetric with this example around the longitudinal axis of the laser beam. Between part 4 and part 5 of the housing part 4 of the housing is an ambient turbulence chamber 1 formed, which radial opposite flowing in openings 11 lead into themselves in the upper portion of the turbulence chamber 1. By the flowing in openings 11 a powder gas stream can become into the turbulence chamber 1 guided in each case, whereby inside the turbulence chamber 1 a mixture, which various powder components can take place if necessary. The turbulence chamber 1 is in its bottom itself conical tapering formed, whereby an inclination angle of the cone should become selected, which avoids an adhesion of powder particles at the inner wall.

With this example the turbulence chamber 1 flows into a bellmouth 8, are 2 present at which again inlet openings for calming channels. The calming channels 2 are, as in Fig. 1 discernible, parallel to longitudinal axis of the laser beam 7 aligned and like in particular in Fig. 2 discernible, radial-symmetric over the periphery with constant distance from each other arranged. The powder with the carrier gas arrives itself then by the cylindrical calming channels 2 into a tapering annular gap 14 conical in the direction of the surface of the workpiece. The cone angle of the annular gap 14 should become with the fact so selected that the coaxial powder hollow jet outgoing from the annular gap 14 meets with small diameter, preferred in its focal point, the surface of the workpiece.

At the housing part 4 a replaceable nozzle tip is 6 present, which is 4 connected with a thread with the housing part here. At least a part of the outside outer surface of the nozzle tip 6 forms the inner wall of the annular gap 14.

At the housing part 5 is at its to the surface of the workpiece pointing side a conical formed outer nozzle 3 present and/or. formed. Also this outer nozzle 3 can be replaceable designed. The inner outer surface of the outer nozzle 3 forms then the outer wall of the annular gap 14. With this construction the clearance of the annular gap 14 can become by corresponding rotation of the two housing parts 4 and 5 varied, whereby one can become the corresponding respective rotation angle more or less large relative movement of the housing parts 4 and 5 in purchase longitudinal axis of the laser beam 7 achieved.

At the part 5 of the housing and in addition at the part 4 in or several connected with one another cooling channels 12, 12' and 13 formed, by some coolant, are preferred water, in particular into the critical part of the machining head to arrive can. The annular cooling channel 13 can do in particular inner part 4 with nozzle tip 6 cool. The cooling channel 12' affected in particular the range of the outer nozzle 3. With this integrated cooling also the heating critical during a treatment of long-terms can be controlled easily.

With such a machining head according to invention z can. B. worn tools again operationally made become. Damaged tool tools, also free forming-flat with complex geometry, can become again manufactured. The order for material on such surface areas requires however highest precision, which can become according to invention achieved with the machining head.

With a worn forging die tool the worn nominal contour of the die engraving can become by means of a digitization system detected and the difference the known target contour determined in a first work procedure. Subsequent ones become the determined difference volume into a variety of horizontal planes disassembled and by means of a Postprocessors the NC programme the control of laser, processing machine with laser working on head and powder promotion generated as well as the strategy for the order for material specify.

In an other work procedure made then the actual repair weld. For this it is required, the material corresponding to weld on the horizontal planes with highest precision, calculated first, and to develop so the missing material volume layer for layer again.

Can become by defocus of the laser beam 7 (Z-position of the focusing optics in purchase to the workpiece surface) a beam spot of approximately 2 mm diameters on the workpiece surface set. Subsequent one becomes the machining head and here in particular the position of the annular gap 14 in purchase the surface of the workpiece so set that the focal point of the hollow powder jet lies on the workpiece surface, so that a very good direction-independentsness also during rapid movements and changes in direction and an high utilization of powder achieved to become to be able.

So a deposition-welding with a powder, z can with such a forging die tool. B. Stellit 21, with a promotion rate from 8 g/min used become. In order to obtain the planar and uniform order crawler-type vehicles, a laser power of 900 W and a feed speed of 600 mm/min, using a CO₂-Lasers, set can become. Bottom these conditions amount to the width of a single crawler-type vehicle 1.6 mm and it is more achievable an high increase from layer to layer in a plane of 0.3 mm.

The machining head according to invention possible one, as already mentions, homogeneous powder distribution of coaxial to the laser beam 7 and it can become an uniform order for material realized, which is also after hundred from single crawler-type vehicles correct. No layer increased heights arise to geometry transitions schroffen on. Also bottom renouncement of zerspanenden intermediate working on can become a very good outline accuracy achieved. The newly formed structure is correct, complete dense and the single layers in the various one above the other formed planes is fixed connected with one another. By the constructional design of the machining head, with the achievable intense cooling, continuous processing times of several hours, can become in stable form, easily realized.